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New records of *Lepidochelys olivacea* (Eschscholtz, 1829) (Testudines, Cheloniidae) provide evidence that Uruguayan waters are the southernmost limit of distribution for the species in the western Atlantic Ocean

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Abstract

We report 8 new records of *Lepidochelys olivacea* marine turtle in the Uruguayan waters, indicating this area as the southernmost limit of distribution for this species in the western Atlantic Ocean. In addition, 1 specimen was subjected to genetic analysis, revealing its population origin in the western Atlantic nesting colonies (Surinam, French Guiana, and Brazil). This report represents an update of the distribution of *L. olivacea* in the southwestern Atlantic and provides insight into the morphological and genetic characterization of the species at temperate waters.

Key words

Olive Ridley Sea Turtle; Southwestern Atlantic Ocean; genetic characterization.

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Introduction

The Olive Ridley Sea Turtle, *Lepidochelys olivacea* (Eschscholtz, 1829), is distributed globally in tropical and subtropical waters (Abreu-Grobois and Plotkin 2008). Although this species is the most numerous sea turtle in the world, it is the least abundant marine turtle in the Atlantic Ocean (Reichart 1993). This is probably due to the late colonization of Atlantic Ocean by *L. olivacea*. Pritchard (1969) suggested that an ancestral *Lepidochelys* taxon was isolated into Atlantic and Pacific cohorts, *L. kempii* (Garman, 1880) and *L. olivacea* respectively, by the formation of the Central American land bridge. Under this model, *L. olivacea* occupied the Pacific and Indian Oceans during the late Pliocene and Pleistocene and recently colonized the Atlantic Ocean entering around the southern Africa (Hughes 1972).

The main nesting areas of *L. olivacea* are located in the eastern Pacific and northeast India, where mass nesting events happen, a phenomenon called "arribadas" (Plotkin and Bernardo 2003, Abreu-Grobois and Plotkin 2008). In the eastern Atlantic Ocean, the nesting grounds

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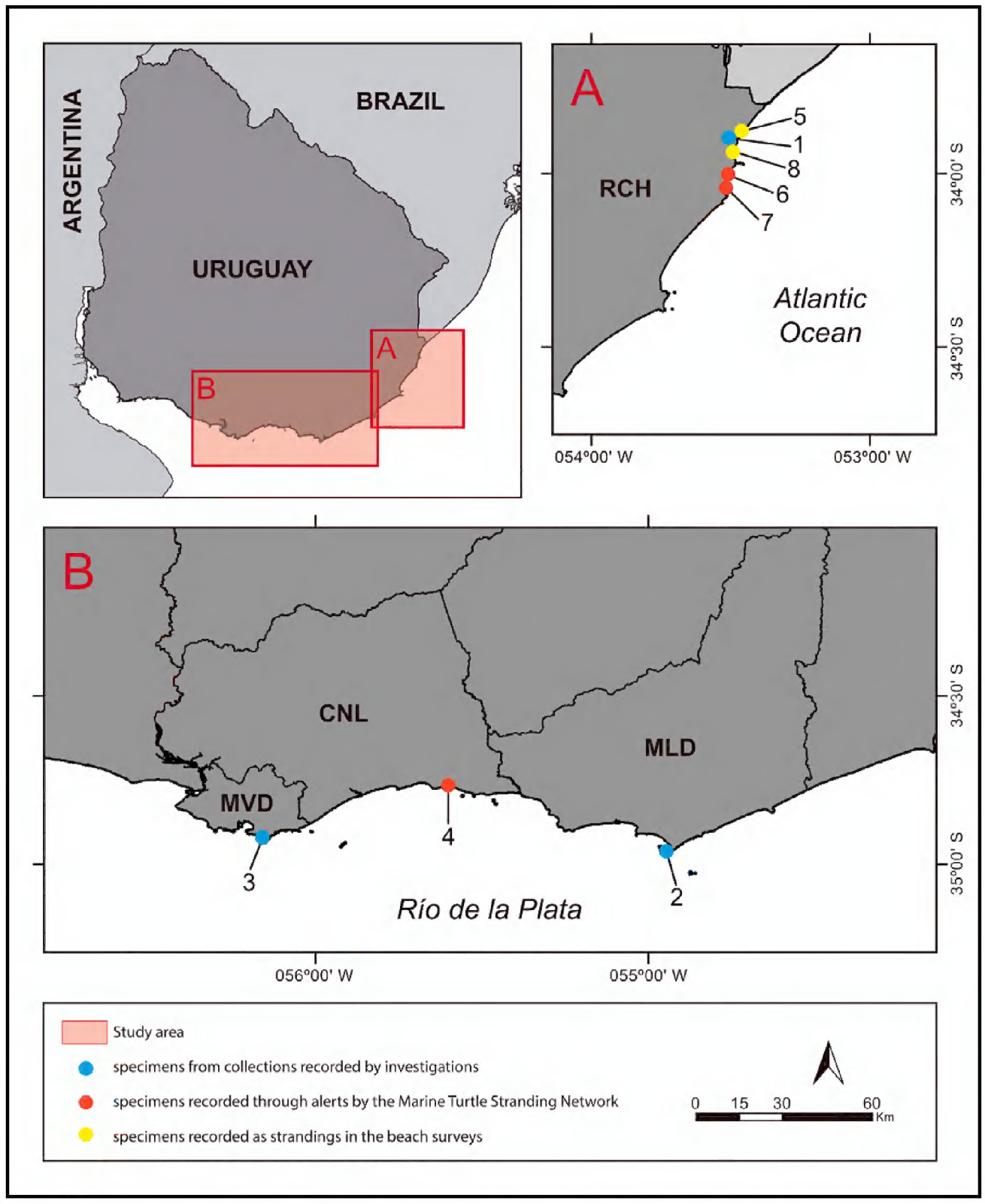

Figure 1. Study area and distribution maps of the *Lepidochelys olivacea* recorded by the Karumbé NGO in Uruguayan waters. Geodetic datum WGS84. **A.** Indicates the record locations for *Lepidochelys olivacea* in the department of Rocha (RCH) in Uruguay. **B.** Indicates the record locations for olive ridley in the departments of Montevideo (MVD), Canelones (CNL) and Maldonado (MLD) in Uruguay. For data on each record, see Table 1.

of this species are along the coast of Africa between Guinea Bissau and Angola and including several islands (Tomás et al. 2010, Maxwell et al. 2011) and, in the western Atlantic, throughout the coasts of Surinam, French Guiana, and Brazil (Schulz 1975, Fretey 1999, Silva et al. 2007). Haplotypes E and F were identified from *L. olivacea* nesting in the Atlantic, based on the genetic analyses of mitochondrial DNA (mtDNA) control region fragments (Bowen et al. 1998, Reis et al. 2010, Hahn 2011).

The geographic distribution of *L. olivacea* extends south into the western Atlantic Ocean; it frequently has been reported from southern Brazil (Soto and Beheregaray 1997, Monteiro 2004). In Uruguayan waters, this species was described as "rare" or "occasional" and its status in Uruguay was categorized as Not Applicable (suspected vagrant; taxon not eligible for assessment at the regional level), according to IUCN criteria (Carreira and Maneyro 2015). The few records available of *L. olivacea* in Uruguay are 2 carapaces (Frazier 1986), 1 bycatch (Laporta and Miller 2005), and 1 stranded dead turtle (Vélez-Rubio et al. 2013). Albareda (2003) considered this species "not present" in Argentine waters.

Lepidochelys olivacea is carnivorous. Its diet consists generally of crustaceans and other invertebrates (Reichart 1993, Bjorndal 1997), and it shows a preference for foraging near estuaries and in bays with high levels of biological productivity. Several tracking studies using satellites have confirmed large offshore movements in search of feeding areas (Polovina et al. 2004, Whiting et al. 2007, Plotkin 2010, Silva et al. 2011, Plot et al. 2015).

Lepidochelys olivacea is categorized as Vulnerable (A2bd) by the IUCN (Abreu-Grobois and Plotkin 2008). Incidental captures in fisheries is believed to be the most important cause of the considerable decline in this species' population in the western Atlantic since the 1970s (Godfrey and Chevalier 2004, Marcovaldi et al. 2006, Domingo et al. 2006, Sales et al. 2008, Silva et al. 2010).

Effective conservation of this species relies on accurate knowledge of its distribution, including characterization of feeding areas and migration patterns.

Table 1. Records of *Lepidochelys olivacea* in Uruguayan waters collected by Karumbé NGO. Data source: C = specimen from collection recorded by investigations, N = specimens recorded through alerts by the Marine Turtle Stranding Network, S=specimens recorded as strandings during beach surveys. Decomposition stage: 0=alive, 1=fresh, 2=without eyes, 3=losing scutes, 4=without scutes, 5=decayed, 6=bones, c=preserved for collection.

Record no.	Date	Department	Location	Latitude	Longitude	Data source	CCL (cm)	Life stage	Cause of death	Decomposition stage	Voucher specimen
1	11 Jan. 2002	Rocha	La Coronilla	–33.9007	–053.5133	C	51.5	juvenile	Incidental capture	Stage C	ZVC-R 5962 [1]
2	22 Feb. 2002	Maldonado	Punta del Este	–34.9658	–054.9496	C	55.5	juvenile	Incidental capture	Stage C	
3	10 July 2003	Montevideo	Montevideo	–34.9015	–056.1778	C	47.0	juvenile	Incidental capture	Stage C	K-LOV-003 [2]
4	28 Apr. 2004	Canelones	San Luis	–34.7773	–055.5850	N	59.8	juvenile	Incidental capture	Stage 1	
5	19 Feb. 2009	Rocha	Palmares de La Coronilla	–33.8387	–053.4688	S	65.4	adult	Unknown	Stage 3	
6	6 Feb. 2013	Rocha	Santa Teresa N.P.	–33.9926	–053.5341	N	69.5	adult	Alive	Stage 0	K-LOV-006 [2]
7	22 Nov. 2013	Rocha	Santa Teresa N.P.	–34.0092	–053.5355	N	—	—	Unknown	Stage 1	
8	7 Feb. 2015	Rocha	La Coronilla	–33.9188	–053.5119	S	64.2	adult	Unknown	Stage 5	K-LOV-008 [2]

[1] Reptile collection of the Seccion de Vertebrados, Facultad de Ciencias, Universidad de la República Oriental del Uruguay (State University of Uruguay).
[2] Karumbé NGO collection.

Methods

The Karumbé NGO has registered eight new records of *L. olivacea* in Rio de la Plata and the Uruguayan Atlantic coast from 2002 to 2017. Thus, this study updates the southernmost distribution of *L. olivacea* in the Atlantic Ocean.

The Uruguayan coast extends 710 km from Barra del Chuy, on the Atlantic coast at the border with Brazil, to Nueva Palmira, inside of Rio de la Plata (Fig 1). The Uruguayan coast is part of a complex hydrological system (Ortega and Martínez 2007) that comprises the frontal zone of the Rio de la Plata estuary and the Atlantic Ocean with a strong horizontal salinity and temperature gradient (Campos et al. 2008, Horta and Defeo 2012). In addition, this area is influenced by a subtropical convergence, a junction of 2 ocean currents, a warm water current from Brazil and a cold water current from Malvinas (Palma et al. 2009). The convergence of water masses, along with the halocline, allows for high biological productivity in Uruguayan coastal waters (Brazeiro et al. 2003, López-Mendilaharsu 2009, Botto et al. 2011, González-Carman et al. 2011).

Data recorded for each record were the following: date, location, geographic coordinates, biometrics (curved carapace length notch to tip [CCL]), and major cause of the stranding or mortality. Using CCL measurements, it is possible to classify an individual's life stage using as reference the minimum size (62.5 cm) of nesting females in the Atlantic Ocean (Silva et al. 2007). Thus, we considered turtles below 62.5 cm CCL to be juveniles, and those turtles 62.5 cm or greater CCL to be adults. The state of decomposition of carcasses were categorized from 0 (alive) to 6 (only bones). When possible, stranded sea turtles were necropsied to determine the cause of mortality.

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For this report, we used 3 different data sources (Table 1):

(A) Carapaces found as decorative items and preserved in good condition.

(B) Stranding events registered by the Marine Turtle Stranding Network of Karumbé. This network coordinates the rescue of sea turtles and records the stranding events along the coast through 24 hours telephonic alerts.

(C) Stranded turtle records were collected during beach surveys by the Karumbé NGO team. Beach surveys are yearly conducted along the Atlantic coast and mainly during the austral summer. These surveys are carried out from December to March because of the availability of trained staff and, when the presence of sea turtles and the potential for stranding events are greater (Vélez-Rubio et al. 2013).

Figure 2. Record 1, a carapace of *Lepidochelys olivacea* found in a restaurant in La Coronilla, Rocha, Uruguay.

Results

New records. See Table 1.

Records 1, 2 and 3 consist of three carapaces found as decorative items, of which the specimens 1 (Fig. 2) and 3 were retrieved by Karumbé members (Table 1)(Fig. 1).

Stranding records included: a bycatch in which the turtle was entangled in an artisanal coastal gill net causing its death (record 4); a rescue alert in which the turtle was found alive (record 6) with the frontal flippers amputated (Fig. 3); and a stranded dead turtle (record 7). Record 6 is the southernmost stranding record of an alive *L. olivacea* in the western Atlantic Ocean to date. The turtle was transferred immediately to the Karumbé Rescue Center for first aid and veterinarian assistance, but after 6 months of treatments, it died due to multiorgan failure (Table 1, Fig. 1).

Figure 3. Record 6, a live *Lepidochelys olivacea* found on the beach at El Barco, Santa Teresa National Park, Rocha, Uruguay.

Figure 4. Record 5, a stranded, dead, *Lepidochelys olivacea* at Palmares de la Coronilla, Rocha, Uruguay.

Records 5 (Fig. 4) and 8 were registered as stranded dead turtles through beach surveys (Table 1, Fig. 1).

Identification. All the turtles recorded in this study were identified as *L. olivacea*, following the morphological keys by Pritchard and Mortimer (1999) and confirmed by A. Estrades and A. Fallabrino, members of the IUCN/SSC Marine Turtle Specialist Group.

Of the 2 species of the genus *Lepidochelys* Fitzinger, 1843, *L. olivacea* has a worldwide circumtropical distribution, while *L. kempii* is restricted to the Gulf of Mexico and the North Atlantic. Adult weight in both species ranges 35–50 kg, being generally heavier *L. olivacea*. *Lepidochelys olivacea* presents a narrower and higher carapace than *L. kempii*, with a dark green-olive coloration and a length of 50–80 cm. In contrast, *L. kempii* has a wider, almost circular carapace, with a light green-olive coloration and a length of 60–70 cm. The carapace of the *L. olivacea* is distinctive in having a variable and often uneven number of lateral scutes, between 6 and 10 pairs, while *L. kempii* always has 5 lateral scutes. Both species present 4 pairs of inframarginal scutes with pores in the plastron, and both species have 1 claw on each frontal flipper. *Lepidochelys olivacea* has a triangular head (smaller than *L. kempii*), whereas the head is subtriangular with convex sides in *L. kempii*. Both species have 2 pairs of prefrontal scales but different jaw structures (Pritchard and Mortimer 1999).

Additionally, a viable DNA sample from the specimen 4 was subjected to a genetic analysis (sample code DNA-K-LOV-004) to verify its identification and to infer the possible origin of this individual. An amplification of the mtDNA control region segment was made by polymerase chain reaction (PCR) using primers LCM 15382 and H950g following the methods of Abreu-Grobois et al. (2006). The result was compared with the haplotypes described for *L. olivacea* in the literature (Bowen et al. 1998, Shanker et al. 2004, Lopez-Castro and Rocha-Olivares 2005, Reis et al. 2010, Hahn 2011, Jensen et al. 2013). The 694-bp long

sequence identified was identical to the most common haplotype found for the western Atlantic nesting populations LO22 (Brazil, French Guiana, and Suriname) and matches the 394-pb haplotype F previously reported by Bowen et al. (1998) in the Atlantic Ocean.

Discussion

In this study, we report 8 new records of *L. olivacea* in the Rio de la Plata and the Uruguayan Atlantic coast registered from 2002 to 2017. These records provide evidence to suggest that the Uruguayan waters are the southernmost distribution limit of *L. olivacea* in the western Atlantic Ocean.

Our genetic analysis of 1 individual provides insight into the genetic characterization of *L. olivacea* in the Atlantic Ocean. Indeed, genetic analysis based on 694-bp mtDNA sequences revealed that this specimen belongs to haplotype F, which is known from rookeries in the western Atlantic (Bowen et al. 1998). This result suggests the western Atlantic nesting colonies (Suriname, French Guyana, and Brazil) may be a main contributors of *L. olivacea* along the southwestern Atlantic. Furthermore, the turtles recorded in this study were subadults and adults, and thus able to swim independently of oceanic currents and cover large distances in search of feeding areas such as the Rio de la Plata and adjacent waters, which is considered as a key foraging ground for many marine species (Brazeiro et al. 2003, López-Mendilaharsu 2009, Botto et al. 2011, González-Carman et al. 2011). This fact and the increase in population numbers at nesting colonies in Brazil (Silva et al. 2007), suggest that these new records represent a possible expansion of this population towards the southern latitudes.

Regarding the carapaces found in this report, it should be mentioned, although there is not a directed fishery on marine turtles in Uruguay, sea turtle bycatch and the use of their shells as decorative items was very common (López-Mendilaharsu and Fallabrino 2001). At present, these practices are considered very rare due to the fact that the illegal use, trade or possession of an endangered species or derivative products is prosecuted by the national (Presidencia de la Nación, Decreto 144/98) and international (CITES Protocol, Appendix I) laws.

The presence of *L. olivacea* at Uruguayan waters might be underestimated due to a lack of data. For example, beach surveys only cover part of the Atlantic coast of Uruguay during the austral summer, missing any strandings occurring on unsurveyed beaches and outside of this time frame. Furthermore, the records of stranding events of Marine Turtle Stranded Network are biased because almost alerts received from the public are from populated areas (Vélez-Rubio et al. 2013). Consequently, some strandings may not be recorded, which represent a loss of valuable data. Thus, we suggest more effort should be directed to the assessment of the presence of *L. olivacea* in Uruguayan waters. This would include systematic surveys along the entire coast and throughout the year.

Understanding the geographic distribution ranges and different habitats used by endangered species of sea turtles is essential for their protection and conservation. These evidences encourage a new assessment of the *L. olivacea* distribution in the southwestern Atlantic Ocean.

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Authors' Contributions

DGP, GVR, and AE conducted field campaigns for data collection and coordinated the Sea Turtle Stranding Network; ATH and MNC collected and analyzed the DNA sample; DGP wrote the manuscript.

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